Sandia National Laboratories

Environmental Program

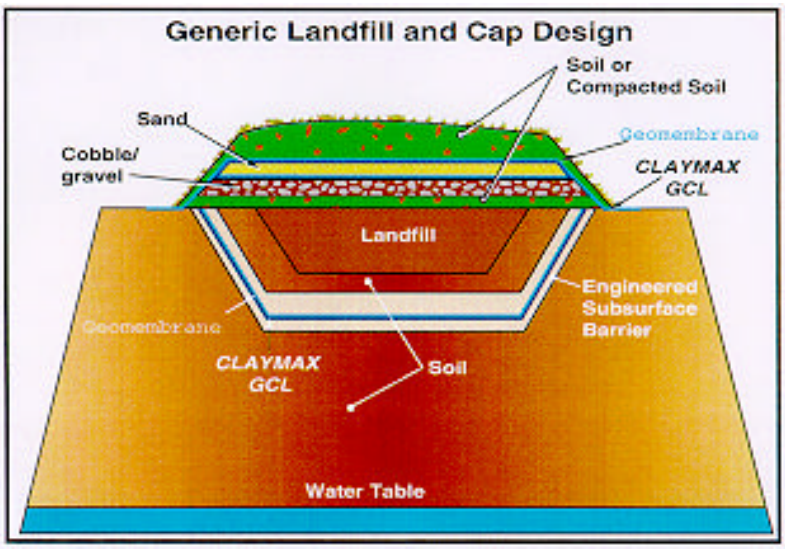
Geosynthetic Membrane Monitoring System

Technology Need

A need exists for monitoring landfill containment systems in situ, especially Geosynthetic Membranes (Geomembranes) whose post-installation status, after put into actual use, is generally unknown. Current practices involve drilling wells to monitor sites. To monitor containment systems in situ, fiber optic lines will be embedded into the geosynthetic membrane which is used for landfill covers and liners. This fiber optic system is called the Geosynthetic Membrane Monitoring System (GMMS). Since the use of geomembranes in geotechnical and environmental applications is widespread and monitoring systems are generally lacking, the potential for this technology is significant. For example, a geomembrane-and-sensor system monitors the behavior of geomembranes used in liner and cover designs.

Objective

The technology of smart structures and smart materials has been developed for defense and space applications. These smart structures have been utilized in monitoring weapons tests, aircraft, naval ships, and the space shuttle. The term "smart", refers to the incorporation of multiple sensors within the structures or materials during construction. The objective of the GMMS project at Sandia National Laboratories (SNL) is to apply the smart structure approach to environmental restoration. As a demonstration of this technology, we have installed prototype monitoring systems in laboratory test frames, and the sensors measured the strains across the membranes as they were loaded. Our objective is to scale these experiments up to the size of landfill cover system using a test cell under construction and utilized during FY 1997.



Project Description

For restoration projects, within the DOE complex, we are designing "smart" landfill covers and linings by incorporating sensors developed in the smart structures applications of the defense and space programs. Such sensors include optical fiber-based strain and moisture sensors. For the landfill applications, we have developed methods to incorporate optical fiber sensor systems with the plastic sheets (geomembranes or geosynthetic membranes) used as engineered components in, for example, landfill liners and covers. A significant need exists to monitor the geomembranes and the surrounding cover or liner materials for the effects of water accumulation, subsidence and age. Fiber optic lines will be embedded into the geosynthetic membranes that are used for landfill covers and liners. Sensors based on optical fibers can

be emplaced to (1) measure subsidence, (2) measure moisture content, (3) measure fluid levels, (4) detect tears in the membrane, (5) detect local subsidence where drums and waste boxes may have collapsed, (6) determine hill slope stability, and (7) monitor road and runway stability.

There are two methods to incorporate fiber optics into a membrane. The first method is to integrate the optical fibers into the membrane during manufacture. The second method is to laminate or glue the optical fibers onto the membrane after manufacture.

A possible sensor configuration in a GMMS utilizes optical fibers with microbends five meters apart of continuous microbend as a distributed sensor. The sensors are emplaced at regular intervals in the fiber optic lines. These lines are crimped into microbend (folded like an accordion) for the movement sensors. Local subsidence where drum or waste boxes have collapsed can be detected when the accordion folds flatten out in response to strains, i.e., stretching or tearing, in the membrane liner. Similar strain sensors are the basis of fluid level and pore pressure sensors. In the future, chemical sensors can be added to the GMMS.

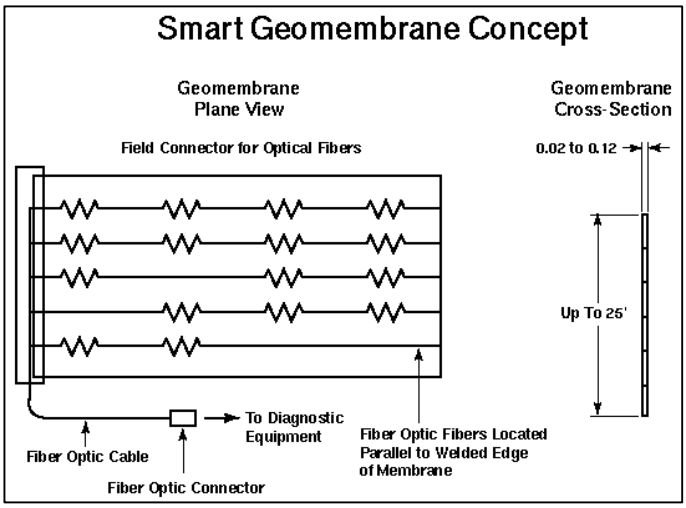
Advantages

The physical characteristics of optical fibers makes them desirable for use with geomembranes and in geomembrane environments. The advantageous characteristics include their small size and minimal corrosion in most chemicals as well as their insusceptibility to stray electrical noise and lightening.

A fiber optic sensor that is incorporated into a membrane can provide long-term monitoring of a landfill with better resolution and actually assist in instrumenting whole elements of the containment system. Fiber optics is a relatively chemical stable method as compared to other methods of monitoring such as lysimeters, Time Domain Reflectometries (TDRs), and porous cups.

Costs

The objective of this portion of the project is to keep the costs of incorporating sensors to an additional 20% of total membrane costs. In 1996 a pilot scale test was conducted which produced a 15-foot wide swathe of the membrane. In 1997 a field test will be conducted. If the tests are successful, the technology could be transferred to private industry for various commercial applications.



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